Planning for a New Manufacturing Plant

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Part I

Preliminary Study of All Factors. In planning for a new manufacturing plant, all factors should be taken into consideration in advance of any action. The selection of a site should positively not be made until after all preliminary studies have been completed, including the study of types of buildings, general dimensions, number of stories for buildings, floor space required, provisions for expansion, accessibility for employes, transportation facilities and costs. All factors have a definite relation, one to another, and should be considered together. Many people buy land first and are thus limited in their planning afterwards.

Methods of Planning or Engineering. In order to reach proper decisions as to the various problems involved in the planning, design and construction for a new plant, the first decision and one of great importance must be as to the method to be pursued in planning and engineering. Four principal methods suggest themselves.

(a) The services of a local architect or local engineer. This may be supplemented by the employment of consulting specialists to pass on various phases of the planning.

(b) The placing of the entire responsibility on one of the large industrial engineering firms who have specialized in the planning of new plants and who generally have large staffs of experts to handle all the different phases of the problem.

(c) The employment of a competent engineer on a salary and on full time to supervise the planning and construction of the new plant. This would rather necessarily involve the use of consulting specialists on architecture, power plant and the various other divisions of the work.

(d) The services of a firm of contracting engineers and builders who would themselves assume responsibility to plan and build the buildings required. This method would probably be considered only where great haste is necessary.

It is wise to give these different methods adequate study and investigation because the decision on this step is of prime importance.

Advantages of the Methods. There are obvious advantages and disadvantages in all of the above methods. The opinions of a manager as to how much of his personal time he should and can give to coöperation with an architect or engineer would have a decided bearing. If the manager is interested in detail and has time to coöperate thoroughly, the first and third methods are generally better and to be preferred. A good local architect or engineer who has time to study the problem diligently will coöperate and give excellent results. There is danger, however, of his following local practice which may not be the best for the particular industry. An engineer or architect on salary will make a more thorough study of general practice throughout the country and determine what is best present practice and what in particular is best adapted to the specific undertaking. The closer the contact with the manager, the better the coöperation and the better the results. Consulting experts can readily be employed to pass on all details. The disadvantage is the difficulty in securing the services of a man with the proper qualifications and also the greater time required in completing the plant. Where the manager is of the opinion that his time can be more profitably employed with other matters and does not wish to go into detail, the employment of a firm of industrial engineers with a countrywide practice can be well considered. These firms have large staffs of experts and can take the entire responsibility of the design and equipment of a plant. There are also firms that combine the contracting end with the planning end and term themselves contracting engineers. Reference to these will be made later. Better time can usually be made by such a firm but probably at a higher cost.

Plan Before Buying Site. After decision has been reached as to the method to be pursued in planning and engineering and after arrangements have been made, too much stress cannot be laid on the fact that the broad general field should be well covered by a comprehensive and thorough study of all details before any decisions are made or actions taken. It may also be wise to consider thoroughly the various general "ideal" plans of buildings

and building arrangements even before looking for a site in order to weigh properly the advantages and disadvantages of each and reach intelligent decisions. One reason for a thorough preliminary study of all factors will be sufficient. To secure the best of light, all manufacturing buildings of more than one story in height should run east and west so as to give one long side to north or constant light. An administration building or a one-story building can run north and south, but manufacturing buildings of several stories should always run east and west. Without due consideration of this important requirement, land might be purchased where this arrangement would be impossible.

Provision for Expansion. No point is of greater importance in connection with a new plant than proper and adequate planning for future expansion. This should be considered in conjunction with every step taken—the purchase of land, the installation of sewers, water pipes, mains through the buildings, the design of the power plant, and all other features. In planning our buildings, we spent eleven months of preliminary work before we bought any land. We secured from the leading insurance groups of the country a list of the one hundred and fifty light manufacturing plants carrying the lowest insurance in the United States and a list of plants which in whole or in part had been built within the preceding seven years. We visited one hundred and thirty-two of the one hundred and fifty plants and compiled a little summary booklet covering every plant and every essential detail in each plant, thus determining at the time as nearly as possible what was "standard practice" as to every feature. Eighty-nine out of the one hundred and thirty-two concerns told us that their chief mistake, as evidenced in the seven years, had been failure to provide adequately for future expansion in one direction or another. This thorough investigation supplied us with data which pointed out many things as in accordance with "good practice."

General Type of Buildings. There are different types of manufacturing, such as heavy and light manufacturing, and these call for different types of buildings. The main point, however, in planning buildings is to erect structures that will meet general requirements rather than to over-emphasize particular processes of any one business. People often make the mistake of trying

to build buildings around some particular detail of process which may change before the buildings have been occupied five years. They accentuate the importance of the particular to too great a degree. In most concerns, processes are constantly undergoing variations, the character of the work and even the machinery in the plant are constantly changing, and a building that is built with general requirements in mind is better than one wherein undue emphasis is given to some specific needs of certain processes or features of the business. Sometimes very heavy machinery is introduced. Later on, light machinery may replace the heavier machines. In other words, even in running a given business, there is often a change in methods, and thus in designing a plant it is well to keep in mind the possibilities of changing the uses of the buildings from those for which they are originally intended. Buildings of a general type, well built and well designed, can be utilized to accommodate almost any manufacturing process. While there are industries that require plants suited to their particular necessities, in many industries general types of buildings are satisfactory. In this second class come most light manufacturing concerns. There are industries such as steel and chemical where special types of buildings are obviously required. There are other industries handling heavy iron or steel materials where assembly shops or erecting floors are required with overhead travelling crane. Even in such cases it will be wise to follow general planning as far as possible and to make provision for expansion and to make some allowance and provision for other possible use in the future. This article, however, in its illustrations and particulars, deals chiefly with buildings for light manufacturing, although many of the general rules apply to planning for all types of plants.

Part II

1. Location and Labor Supply
2. Railroad Facilities
3. Water Supply
4. Sewer Facilities
5. Salability

Location and Labor Supply. Most concerns think only of cheap land and go to the outskirts of the city and buy real estate there. In locating a plant, it is very important to consider the type and character of the workers apt to be employed. If

high-paid, skilled men are engaged, a plant might to very good advantage be located on the outskirts of a city because men earning very high wages will not hesitate to go any distance to work. Furthermore, such men are home builders and will in time build or secure homes near the plant. In case a concern uses chiefly girl labor, or boys and girls and a good deal of unskilled labor, then great consideration must be given to its accessibility to employes. The importance of this feature can be emphasized when we realize that a concern may pay more in one year for extra wages than the ostensible saving on the cost of the land. The first cost of the land is a very small consideration when one figures what it may be necessary to pay out annually in wages by reason of a wrong location. When employes have to pay sixty cents to a dollar per week for carfare and have to take with them or buy their lunches, they expect to get paid for it. Many instances are known where plants on the outskirts of the same city are paying girls one dollar per week more than are other plants rightly located near the homes of the workers, the difference being due solely to difference in accessibility. Furthermore, people do not like to waste thirty to sixty minutes going to work and a similar period coming home. They give preference to a business which is within easy walking distance. Accessibility thus gives help at a lower wage and gives the pick of the best help. For a plant having approximately a thousand employes, one dollar per week additional in wages because of poor location means over $50,000 loss per year. It can thus be seen that there is an important relation between the land and the wages, for a cheap land location may prove a very expensive one in the end. The low cost of land is not of great importance in locating a new plant and too much stress should not be laid on it. Most concerns are perfectly justified in paying if necessary a very high price for a good location. Of course, land on the outskirts of the city will increase proportionately more in value than land nearer the center, but the latter, if well chosen, should never be worth less and should even increase gradually in value. In general, it may also be said that workers in going to work like to go towards a good section of the city rather than towards and into a very poor section, and other things being equal, this fact should be given consideration.

Railroad Facilities. The emphasis on the value of a location on a railroad track or siding is sometimes exaggerated. There are not so many concerns that buy and receive their materials and ship their products in carload lots. Coal for the operation of power plants, however, should always be handled by the carload. The advantages of a location on a railroad are thus not so great as people are prone to think they are. It should be said, however, that frontages on railroads maintain their values best and the salability of a plant is usually materially enhanced by being so located.

Water Supply. One other point to bear in mind in securing a location is the availability of a good water supply, both as to quality of water and adequacy of supply. In order to provide adequate fire protection, the insurance companies require that two sources of water be available. In the usual cases, one supply is furnished by the city or community and the other provided by the owner, either in the form of a tank or an underground reservoir with fire-pump.

Sewer Facilities. The sewer facilities of a site should be carefully considered, both as to depth and capacity.

Salability. In connection with location, future value or "salability" is worthy of due consideration, but this point merely again emphasizes the wisdom of good general planning as against planning for some particular requirement. "Salability" is affected by such things as location on railroad, heavy floor load capacity, general character of design, large window areas and ample provisions for expansion.

Part III

1. General Design for Future Use
2. General Plan for Grouping of Buildings
3. Layout with Reference to Administration
4. Theory of Light
5. Underground Piping

General Design for Future Use. In planning a new plant for light manufacturing it is wise to emphasize that the plans should be good for any light manufacturing business and not for the particular business. In most cases it will be found that particular processes in light manufacturing can in truth be well adapted, if not better adapted, to buildings of a good general design than

to buildings emphasizing particular design and construction. Conveyor systems can also be installed in the general type of buildings where required and yet permit of future change. The good general design has the great advantage of flexibility, on the whole better adaptability, and is decidedly the best for future changes and future use.

General Plan for Grouping of Buildings. This article deals with the assumption that the site selected will be much larger than required in the beginning and thus provide adequately for expansion. This means then that there will be in the end a group of buildings or large additions to those first built. Theoretically, the ideal site would be a perfect square and the plans for future buildings would be such as to fill the square. This might be accomplished by an arrangement of buildings that would when completed be represented, say, by the letters U H E, or by a double H or a double E, and at intermediate stages of construction by the letters I T L F. In all these types of buildings, the departments may be so arranged that materials and parts in process may travel in two or more directions without re-entrant lines on their way toward final assembling. Moreover, different lines of goods can be made in the various wings without interference and brought to a common point for storage and shipment.

Layout with reference to Administration. In the case of any light manufacturing business, the choice of a building has to do more with good light and efficient administration than with the processing. Parts are usually small and are handled in large quantities and the shape of the building is not so important in its relation to the handling of the material. In considering the layout of buildings with reference to administration, it may be stated that considering this feature alone the ideal condition for any business would be to have the administration and general departments near the center of the plant. The ideal point of administration, control and direction would obviously be that point nearest to all operations. This can be illustrated by a plant having when finally completed a central administration building running north and south with, say, six long manufacturing wings running east and west, three on each side. In any event the arrangement and grouping of the buildings should be contrived as far as possible so that at all stages of development

of the plant the administration shall be as central as possible. The grouping of buildings should, moreover, be such that at every particular stage of development the plant is, if possible, complete in itself. It is obvious that unless the buildings are grouped logically with reference to each other and to the administrative departments, considerable lost motion is bound to occur. This means waste, for if work has to pass and repass itself in process, more truckmen and more floor space are required to handle it expeditiously than is the case when the route from raw materials to inspection and shipment follows a straight line without re-entrant angles.

Theory of Light. Clear, direct light comes from the sky. The sky can be considered as a great reflecting mirror throwing light on the work. Theoretically, ideal conditions might call for buildings so arranged, spaced so far from each other and with such high ceilings, that the sky as a reflector would throw direct light on work placed on tables in the center of the ground floor. If this were so, direct light would then be present in every part of the building and on every bit of work. For practical purposes, the light rule in arranging buildings can be considered as an angle of forty-five degrees. That is to say, buildings should be spaced a distance from each other equal to their height. If clear, direct light is required, it is obvious that it can be obtained only in buildings of several stories and relatively narrow in width. In a one-story building with saw-tooth roof construction, the only direct light is from the side windows. The saw-tooth roof gives only indirect or deflected light. Such buildings, however, while not giving such good light, do give a rather uniform diffusion of light. When manufacturing buildings run east and west, we have the most constant light conditions. The south side always has sunlight and the north side is always free from sunlight and especially suited for all work of inspection and shading. In light manufacturing it is usually quite easy to lay out departments so that such work will come on the north side and machine work in a large measure on the south side. The street or streets on which a site is located should be considered in planning as having light value. Where the street is very wide, the eventual buildings can come nearer the street line. Where the street is narrow, the building line must be set back from the street line.

Underground Piping. In the planning of no other particular is it more important to have the possible, final and completed plans fully in mind than in connection with planning for sewers and underground piping. Very thorough provisions should be made for all possibilities of expansion and it will not be unduly expensive to make adequate installation in the beginning, if the planning has been carefully and properly done.

PART IV

1. NUMBER OF STORIES
2. GROUND FLOOR
3. LENGTH AND WIDTH
4. COLUMNS
5. CEILING HEIGHTS
6. FLOOR LOADS
7. FLOORS
8. WINDOWS
9. STAIRWAYS
10. STORAGE AND LOCKER WING
11. TOILET ROOMS
12. POWER AND HEATING PLANT
13. SIMPLE EXTERIOR

Number of Stories. It is obvious that in considering any plans as to buildings, an early decision must be made as to whether the buildings shall be of one story or several stories and if more than one story, how many. Comparing equally good character of construction, a one-story building is more costly than one of several stories; is more wasteful of ground area; has less direct light, and has some disadvantages in administration. In general it is easier to walk up a flight of stairs than to walk several hundred feet through departments. The problem of ventilation is also difficult in a one-story building and operators on the whole rather object to the closed-in effect of a single-story building. There are, however, types of industry that call for one-story buildings, but for light manufacturing in general, the building of several stories is preferred. As to the number of stories the three main factors are: utilization of the land area, the cost of various types of construction and the use of stairways and elevators. In general the higher the buildings the more economical the use of the land, but if the ideal light rule is followed, this is not so important as it at first might appear. The higher the buildings, the further apart they should be spaced. Thus, if it is desired to meet ideal light conditions, the additional story-height of buildings does not appreciably reduce the amount

of land needed. The type of construction and its cost has large bearing on the number of stories. The higher the buildings, obviously the lower the cost for the roof in proportion to the total floor area, but the larger the cost for foundations and columns. A study of the relation between cost of foundations and columns and cost of the roof in the various types of construction is thus involved. Figures prepared some time since, all factors considered, indicated that for mill construction buildings, the minimum of cost was obtained in a three to four-story building; in reinforced concrete, the cost did not show any material decrease when over four or five stories; and in structual steel reasonable economy was found at about six stories. It has been found that in four-story buildings employes can be required to use the stairways and walk. This means at the most the use of three flights of stairs. When we get to a five-story building, a passenger elevator for employes is found to be absolutely necessary and then that the elevator service will have to be made available for use by all who work on the third, fourth and fifth floors. These various reasons have led to the very general adoption of the four-story building as standard. It is obviously desirable that all stories be of the same height—in other words, uniform.

Ground Floor. The advantages of erecting buildings entirely above the grade have in the past been often overlooked, although the general practice is now so to build factory buildings. There is very little difference in cost between buildings in which the basement floor is several feet below the grade and those built above the level. The generally approved plan is to have the first floors of the buildings about one foot above the grade and this saves lowering and raising materials and product, and makes the first floor quite as good for manufacturing purposes as any other—a very desirable feature. As to buildings erected in congested areas where the entire land is occupied, an exception may be made to this rule. On properties where there is a marked grade or on properties facing on streets with different grades, the first floor may be laid out so as to be only in part above grade. There should be under the first floor, however, adequate subways and tunnels for heat, water and live steam pipes, for electric wiring and for the heating and ventilation systems.

Length and Width. In connection with the floor plan of a building—namely, its length and width—several things are to be noted. As to the length, the main factors on which decision should be based are cost and supervision. The minimum cost obviously decreases with the length, rapidly at first—less so the longer the distance—and the saving is not relatively great after, say, three hundred feet of length. One end wall is involved, and if this encloses twice as much area as otherwise, the cost of the wall in relation to the whole is only one-half. It has been found that supervision of a floor is limited in most cases to three hundred feet or less. Buildings three hundred feet in length have been quite common, but if the entire plant is very large, there is no good reason why buildings should not be six hundred or even eight hundred feet long. The width of floors is determined chiefly by cost, the light factor and the character of the work. In general the wider the floors the less the cost, but the poorer the light. The light factor depends very largely on the ceiling heights. With very high ceiling height the building can have greater width. Where a great deal of inspection work or delicate assembly work is involved and light becomes of prime importance, the width may run down to thirty or forty feet, as has been the practice in watch factories. In textile mills where the machinery is a factor the width may run up to eighty and one hundred feet. In general the tendency is towards wider buildings. The forty and fifty-foot buildings of the past have given way to buildings about sixty feet wide. If the ceilings are unusually high, however, or if the character of the business involves much storage in transit, the width may run up to seventy or eighty feet. The column spacing will then become a factor. It is obviously ideal to plan so that all buildings shall be as far as possible uniform as to length and width.

Columns. It is obvious that the less the space occupied by interior columns the more desirable and convenient the floor space for manufacturing. In mill construction buildings it is necessary to have more columns than in reinforced concrete or structural steel buildings. In the two latter types of buildings a twenty-foot spacing is economical and good practice. A building three bays wide (two rows of columns) has, usually, a more convenient interior than one with two bays or four bays with a row

of columns down the center. In the first case the two outer bays are used in general largely for machinery and operations, while the center bay is used more largely for aisles and storage. In a building eighty feet wide with twenty-foot column spacing, the two outer bays are no larger than in a building sixty feet wide, and then we have two interior bays instead of one. It is quite possible, however, in reinforced concrete and structural steel buildings, to have spacing of columns greater than twenty feet.

Ceiling Heights. In a building sixty feet wide, it is possible to get a fairly satisfactory diffusion of light with a ceiling of from thirteen to fourteen feet. In reinforced concrete buildings of flat slab construction and with no beams or girders, and where the windows are brought right up to the ceiling, twelve-foot ceiling heights are to be considered. A slight increase in the height of the ceilings does not add greatly to the cost per square foot and the added height has many advantages. Where there are many employes per given floor area, as in some textile industries, high, airy ceilings are worth more than their extra cost. By making ceilings fifteen to sixteen feet high, better light is secured for all time. This is desirable for the immediate as well as for any possible future use and it creates for the workers a sense of space and cleanliness that is most desirable. This extra height, moreover, has a very great justification in the fact that it makes possible the installation at any time of a mezzanine floor on any story, at any point or over any part of a floor. With this ceiling height, there will be ample head room both above and below. The advantages of a sufficient ceiling height for the installation of mezzanines cannot be well overstated. The mezzanine permits at any time immediate expansion with practically no re-arrangement. Where used to relieve congestion, it is storage that is usually moved to the mezzanines. The mezzanine can, however, be used advantageously for storage at any time. No matter with what care the processes through a plant may be laid out in sequence and with due economy of space, there will come times when changes in process or in demand will greatly overload some step in the process. The alternatives are to re-arrange entirely nearly all the processes, to take one process in whole or in part entirely out of the chain or sequence, or to get quick relief through the use of the mezzanine. As buildings grow older their value

will be enhanced by the ability practically to double the floor space without great cost.

Floor Loads. In the planning, due study should be given to the floor loads required. In the design and construction of a building it is obviously desirable, except for cost factors, to provide for heavy floor load capacity. Such capacity makes for durability, greater flexibility in the future use of the buildings and for freedom from vibration in connection with high speed machinery. If only very light floor loads are involved and no high speed machinery, then greater consideration may be given to mill or timber construction buildings as will be referred to later in this article. However, if the buildings are to be of reinforced concrete, it is possible to secure capacity for heavy floor loads without greatly increasing the cost. Calculations thus as to floor loads may be a very large factor in determining the type of construction to be adopted. In planning the floor loads to be adopted, it is wise to get adequate estimates as to the extra costs for extra heavy floor capacities. These estimates may reveal an extra cost so slight as to be well justified. The floor loads provided for should be adequate to support eventually a mezzanine as suggested.

Floors. Wood floors are most widely used. It has been proven, however, that concrete when properly laid and properly treated is very satisfactory and its popularity is increasing. To lay wood floors over concrete in reinforced concrete buildings is very expensive, unnecessary and not generally recommended. Concrete floors on the whole provide the best foundation for machinery. Great care should be used in drawing specifications covering how the concrete floors are to be laid. When floors are subject to the action of acids and chemicals, special study of conditions and requirements becomes necessary. Composition floors of various kinds have been used to a certain extent in Europe and their use in this country is increasing somewhat.

Windows. In general, it is desirable to have large window areas and perhaps the maximum window area. It is also a wise provision to have, as far as possible, uniform size panes of glass; this makes not only for regularity in design but for economy when replacement is necessary. The use of steel sash with rolled sections has almost superseded all other types and if glazed with

wire glass in exposed locations—if any such—offers excellent fire protection. The small pivoted ventilator sections do not provide ventilation so readily as the sliding wooden sash and are more difficult to shade and clean. The advantages, however, usually offset the disadvantages. The various types of sheet metal sash are generally too expensive for general use. The use of ribbed or sanded glass is not recommended. It is objectionable where very accurate light conditions are required, by reason of a certain glare produced. Workers strongly object to it and want to be able to see out of doors, and there is a belief that there is a rest value in permitting them to do so.

Stairways. Where possible, stairways should be outside of manufacturing floors, leaving the manufacturing space a perfect rectangle. This can be accomplished by placing stairways in a projecting wing or in a wing connecting two manufacturing buildings. These wings are also frequently used for locker rooms, toilets and storage rooms as is mentioned hereafter. In locations where the climate is not too severe the so-called Philadelphia stair tower, where the approach to the stairway is through a loggia or alcove open to the weather, is excellent as an extra protection to employes in case of fire. With adequate ceiling height as recommended, a double stairway, sometimes called the "scissor" type, can be used, doubling the capacity without increase of floor space. A stairway should be wide enough for a double line of travel and not wide enough for three or more abreast unless there is an intermediate handrail. Experience has shown forty-four inches to be almost ideal for a double line. Some type of safety tread should always be used unless the tread is constructed of a non-slippery material.

Storage and Locker Wing. A most excellent feature in connection with a modern factory building or a group of factory buildings is to combine all stairways, elevators, toilets, storage rooms and locker rooms in a separate building or wing or in a connecting building; this to be provided with mezzanine or half-floors—two floors, in other words, for every manufacturing floor—and to have the space for toilet, storage and locker purposes planned originally in common and so that there may be free and large expansion for any one of them. The advantage of this can be illustrated by the following. In cases where workers may finally

be employed chiefly on the second floor, storage could be removed entirely from the first or ground floor of the wing, from the mezzanine between the first and second, and from the second floor of the wing, and the space on these floors used exclusively for lockers and toilets, permitting on the second floor two or three times the toilet facilities on other floors. Using the separate wing for these purposes is the ideal plan. A separate wing or connecting building, from a fire prevention standpoint, isolates each floor and at the same time gives clear unbroken manufacturing space on each and every floor.

Toilet Rooms. It is impossible to plan in advance the maximum requirements for toilet rooms, due to the impossibility of fully determining the number of employes that will be required at any one point of the buildings several years after their construction, unless an absurd and unreasonable amount of equipment is provided in advance at various points. The best plan is to install liberally what is needed at the moment, but have space available and so located that the toilet rooms can be doubled and tripled in size when need arises. This involves proper preliminary planning for expansion as to water piping and sewers. There are many advantages in having separate toilets for different departments or classes of labor. Thus it may be wise to plan so that two and even three separate toilet rooms may be placed near one another, instead of merely enlarging the existing one. A general plan for a large wing or connecting building with mezzanine floors and with large space in common available for storage, lockers or toilets makes all this possible.

Power and Heating Plant. The determination here will rest upon the decision as to whether power is to be made or purchased. If there is little use in processes for the exhaust steam from a power plant, it may be found advantageous to buy the power required and install merely a low pressure heating plant for use in winter. These factors are also to be considered. If the power load is a very steady load through the day and with no peaks, power can be purchased cheaper than otherwise. Again, if there is night use for power this will further reduce the cost of power purchased. In many instances power can be made cheaper than it can be purchased, but this point should be clear: the cost of power made is low only when installation is being used reason-

ably well up to capacity. This is due to the fact that cost of power made includes, as very heavy factors, interest on investment and adequate depreciation charges. Thus, if at any time, for example, only fifty per cent of power capacity is being used, it is not unlikely that the cost exceeds that at which it could be purchased. Assume that the original installation provides for capacity twenty per cent over immediate requirements. If the business falls off, the power cost will go up; on the other hand, if the business grows rapidly, an addition to the plant will be required and it may be of such size as to make the amount then used out of total capacity rather low and the cost high. Two points should be emphasized: the wisdom of providing intelligently and adequately for expansion in connection with any power or heating plant and the wisdom of having power plant specialists study and consider this problem with great care.

Simple Exterior. The exterior of a factory building should truthfully express in a simple direct form that it is a factory building. Architectural ornament, in the sense of unnecessary expenditure in that direction, is not appropriate or desirable. Neat, simple lines, not involving an extravagant outlay, are far more dignified and pleasing than ornate decoration. Nevertheless, it is to be noted that by a careful study of design and costs, some very simple and yet attractive architectural features can be added at a very low additional cost.

PART V

1. TYPES OF CONSTRUCTION
2. COMMENTS ON TYPES OF CONSTRUCTION
3. METHODS OF CONTRACTING

Types of Construction. The various types of construction used for industrial plants may be classed as follows:

(a) Frame Construction
An all wood construction.

(b) Ordinary Construction
Masonry walls, wooden or iron posts, thin wood joists and thin wood floors.

(c) Mill Construction
Masonry walls with heavy wood columns and heavy wood girders spaced close enough for a thick wood floor to make the span without intermediate beams.

(d) Semi-Mill Construction
A modification of mill construction with a wider spacing of columns and girders and the use of heavy beams spanning from girder to girder.
(e) Slow-burning Construction
A modification of one of the above classes with an additional protection of metal lath and plaster.
(f) Reinforced Concrete Flat-slab Construction
All reinforced concrete with thick slabs, no intermediate beams or girders, columns spaced up to twenty-five foot centers. A particular flat-slab construction has been termed "mushroom" construction.
(g) Reinforced Concrete Beam and Girder Construction
All reinforced concrete with beams and girders.
(h) Structural Steel Construction, non-fireproofed
As usual in one-story buildings.
(i) Structural Steel Fireproofed Construction.

Comments on Types of Construction. Frame construction is very little used today. Ordinary construction is considered only where very light floor loads are required, where fire protection is not a factor and where there is little machinery or very little high speed machinery. Good manufacturing buildings are usually of

1. Mill Construction
2. Reinforced Concrete Construction
3. Structural Steel Construction.

The selection of the type of building or materials of construction requires careful consideration. The mill construction type was originally introduced in New England textile factories and favored by fire insurance companies. It has a fine fire record and carries a very low insurance rate. In sections of the country where heavy timber is not too expensive and where heavy floor loads are not essential, it is still a very desirable construction. It is usually rapidly erected and building work can be carried on in winter weather. Reinforced concrete has in recent years largely superseded other methods, particularly for multi-story buildings, and for heavy floor loads compares very favorably in cost with mill construction. There are advantages for both types of construction and the question is involved as to whether or not a wood top floor is necessary. These questions have to be settled for the particular industry. While concrete work can be carried on in winter it is done at a disadvantage and at extra expense.

The difference in cost as between buildings of good mill construction and reinforced concrete is not great. The main factors are the floor loads required, the need as to wood top floors and in some instances local labor conditions. The mill construction may be slightly more economical than reinforced concrete, but only when designed for light floor loads. For one-story buildings with saw-tooth, monitor or gable roofs, or for one-story buildings such as power houses, non-fireproofed, structural steel has much to commend it, but for a multi-story building where fireproofing is necessary, the high expense usually precludes its use and in many particulars it is not considered as good for buildings as reinforced concrete.

Methods of Contracting. There are three general methods under which contracts for construction are usually let.

(a) Competitive contract
(b) Non-competitive contract
(c) Cost plus a percentage or fixed profit.

When drawings and specifications have been prepared by a competent engineer or architect and the work is to be under competent supervision, competitive proposals can be secured from a selected list of contractors and a contract can nearly always be made with an experienced reliable contractor at a fixed amount. There is very little question but that this is the most economical method and, unless time is the all important factor, the more generally satisfactory. In this connection, a word might be said as to general or separate contracts. Local custom has a bearing and must be considered. In many cases contractors are organized to take several lines of work and in other cases a general contractor will be, for instance, a mason and will sub-let all other work. The general contract centralizes responsibility, but does not usually give the lowest combination of proposals and in many cases brings in undesirable sub-contractors. There is apparently a tendency to let separate contracts for various divisions of work such as mason, carpenter, steel, heating and plumbing. In many cases satisfactory non-competitive contracts have been made, particularly for some type of standard building to be erected within a certain time limit. This method frequently precludes proper study and the cost benefit of competition. It is desirable only where time is all important. Within recent

years many large organizations of contracting engineers have been built up that furnish an engineering service, or work from plans of other engineers when necessary, and take contracts to erect on a cost basis plus some form of agreed profit, usually a percentage on cost or a fixed sum. This is apparently a very fair method and wonderful results as to speed have been made. Unfortunately it seems to have a somewhat demoralizing effect on both workmen and contractors and in many cases costs have been unduly large.

PART VI

1. SPRINKLER SYSTEM
2. INTERIOR FIRE PROTECTION
3. EXTERIOR FIRE PROTECTION
4. FIRE ESCAPES
5. PARTITIONS
6. SHELVES, TABLES, BENCHES, ETC.
7. SHAFTING AND SUPPORTS
8. MANUFACTURING EQUIPMENT
9. OFFICES AND OFFICE EQUIPMENT
10. POWER DISTRIBUTION
11. HEATING AND VENTILATION
12. LIGHTING
13. ELEVATORS AND CONVEYING MACHINERY
14. STORAGE SPACE
15. LOCKER ROOMS
16. LOCKERS
17. LUNCH ROOM
18. SAFETY APPLIANCES
19. SANITARY CONVENIENCES
20. HEALTH CONTRIBUTING ARRANGEMENTS
21. FACTORY GROUNDS

Sprinkler System. No modern building will be designed or built without a proper and adequate sprinkler system. The saving on fire insurance is too large to be ignored, but the protection to the plant is of even greater moment. The home offices of the insurance companies should be asked to pass on the plans for such a system in advance of any final decision.

Interior Fire Protection. In addition to the automatic sprinklers above mentioned, fire protection would see to it that water buckets and chemical fire extinguishers are available at regular places throughout the plant to check incipient blazes. Woodwork about a plant should also be eliminated as far as possible and metal used instead. There is no better protection against fires than cleanliness and any appliances and conveniences to this end such as vacuum cleaners should be carefully considered. Metal receptacles for waste and refuse will of course be provided.

Exterior Fire Protection. The insurance companies will suggest

and determine requirements as to exterior hose houses, yard hydrants, water tanks, underground reservoirs and fire pumps.

Fire Escapes. Exterior fire escapes are unnecessary in a building properly planned. The number of stairways and their location in buildings is now usually determined by law. Stairways located in towers or wings as suggested make fire escapes unnecessary.

Partitions. It is recommended that interior partitions be of a standard metal type and built in standard sections. Buildings with all stories of uniform height and width and with columns uniformly spaced make this very feasible. Metal partitions are very desirable from the fire protection standpoint and are movable without loss as changing conditions arise.

Shelves, Tables, Work benches. It is most desirable that standards for all this kind of equipment be adopted and adhered to. In so far as possible metal should be used and it will be found that this can be done without any material increase in expense.

Shafting and Supports. If buildings are to be built of reinforced concrete, sockets for bolts should be imbedded during construction in all the ceilings throughout the plant at points rather close and uniformly spaced. To do this at the time of construction will result in a very great subsequent saving. Partitions, shafting and the eventual mezzanine floors can be attached to these sockets quickly and inexpensively and without cutting or drilling into the concrete floors. Shafting supports should be uniform and standard.

Manufacturing Equipment. It is somewhat beyond the scope of this article to discuss in detail the subject of manufacturing equipment. It may, however, be safely stated that a good new manufacturing plant logically calls for modern labor-saving machinery, properly arranged and economically driven.

Offices and Office Equipment. The open office is preferred and is coming into more and more general use. Flat-top sanitary desks are recommended. A central filing vault with metal filing cases is not uncommon. The employment offices should be adequate, and properly planned and laid out.

Power Distribution. Electric distribution of power is almost universal in some form or other. This is true with the possible exception of a few special instances such as a rope drive in some

textile plants. Careful study is, of course, necessary in each particular case as to whether a motor will drive only one machine or whether it will drive a shaft to which a group of machines may be belted. In all cases conduits and electric feed mains should be of sufficient capacity to allow for very large expansion and changes.

Heating and Ventilating. In addition to lighting, nothing contributes more to the comfort and efficiency of employes than satisfactory heating and ventilation. Three general methods of heating are direct radiation, indirect radiation and a combination of the two. By indirect radiation is meant some form of fan or blower system. Where direct radiation only is used and the number of employes large, ventilation is not satisfactory. Where an indirect system only is used, difficulty is sometimes found in heating remote points. A combination of both direct and indirect radiation is more costly, but more nearly approaches the ideal. The radiators are usually heated with steam, but sometimes a pumped circulation of hot water has been effective and a method of combining an automatic sprinkler system with hot water radiation has been recently introduced. In connection with an indirect system, apparatus for air filtering and conditioning is frequently used. The effectiveness of a heating system is greatly increased by double or storm sash at exposed points.

Lighting. The method of artificial lighting will require careful consideration. Illuminating engineers have now well established rules for the intensity desirable for nearly all kinds of work. General illumination is now almost universally the preferred method of lighting. This may be of several types—either direct, indirect or semi-indirect—and is sometimes supplemented by additional small lights where great intensity is necessary at one point. An illustration of this is a small light shining directly on the needle of a sewing machine in a clothing factory. Provision should be made for changes in occupancy and for expansion, and conduits and electric feed mains should be planned and laid out with this in mind.

Elevators and Conveyors. Elevators are placed preferably in a separate wing so as not to encroach on manufacturing space. They usually can be conveniently located in the storage and locker wing previously mentioned. Building laws are quite explicit

as to construction of elevator shafts, doors and safety devices. In a building of not over four stories, as recommended, passenger elevators are not necessary. Conveyors are such a special requirement that little can be said. In many cases material can be conveyed in crates or boxes on trucks and elevators with greater economy. Gravity conveyors have in many cases proved very satisfactory. In general the efficiency of conveyors is apt to be overstated.

Storage Space. The storage spaces within the main or manufacturing buildings should be only for goods in work or in transit. Such spaces are absolutely necessary in most departments in order to insure an even flow of work, but space for goods in transit should be limited by definite determinations forcing all extra or surplus stocks into the storage spaces in the storage and locker wings. All storage of old and extra machinery, boxes, surplus equipment and materials should be in the main storage spaces provided in the storage and locker wings.

Locker Rooms. In general, the objections to a single large locker room on the ground floor are valid. It is better to group departments and classes of labor in separate locker rooms and this is preferred by labor. A single room on the ground floor may be a waste of space in the beginning and in the end not readily capable of being expanded. It also means crowding on stairs and at exits at closing times. Separate locker rooms on the various floors of a separate wing having mezzanine floors distributes the rush on stairs and at exits upon leaving the buildings.

Lockers.—There is no known perfect solution of the locker problem. If the expense can be borne and is no great object it is best to install individual lockers, but stealing will go on even with lockers and after a period of time experience has shown that perhaps not over thirty per cent of the lockers will be locked. However, if the locker has been provided and loss occurs through failure to keep the locker locked, responsibility cannot well be placed on the company. The use of small locker rooms for different departments tends to place responsibility for stealing on a limited group and thus checks it. Many concerns have separate coat rooms for different departments and provide ordinary racks for hats and clothing instead of lockers. It may be advisable to establish and maintain a check room near the main entrance

where employes can check small articles of value at company responsibility.

Lunch Room. This feature is a necessity in the modern plant. It should be on the ground floor and near the general exits. In general it has been found that employes will not go upstairs to a lunch room. It should be directly accessible after working hours without passing through other portions of the plant. It should be considered, moreover, as more than a lunch room. It is the assembly hall for the plant. It is a place for dances, concerts, dramatic entertainments and such other uses as may properly suggest themselves to the employes. It would not be inappropriate or undesirable to have a platform or stage at one end of the room. The lunch service usually follows the best accepted practice in cafeterias. The equipment in kitchen and behind the serving counter should be adequate and installed under the direction of specialists on factory lunch rooms. The rest of the equipment such as chairs and tables should be simple but very substantial. Small tables are preferable to long narrow tables which suggest an institution. A small octagon or circular table accommodates four people under usual conditions but can conveniently be used by five or six. The one lunch room should be used by all. Separate lunch rooms for the office workers, officers and heads are not favored.

Safety Appliances. The question of safety appliances will in a large measure be determined by the nature of the particular industry. The Safety First movement in America has developed excellent information and data on this subject which is available and will be duly considered in connection with all new installations. Adequate exits with wide halls leading to them will of course be provided; stairs will have proper guard rails and safety treads as previously suggested and elevators will have automatically closing doors. Fire exits will be properly marked.

Sanitary Conveniences. Most modern factories with a proper heating and ventilating system, with good lighting, with good toilet facilities and cleanly kept from the sanitary standpoint, compare favorably with even the best of homes. In addition to the particular things mentioned, however, there should be provided adequate washing facilities with hot and cold water. There should also be drinking fountains or stations for distributing

water to employes—in either case connected with a water cooling-system. The power plant should be provided with a smoke consumer, and throughout the plant, wherever there is dust or dirt arising from operations, there should be installed the most efficient dust-collecting systems. Too much emphasis cannot be placed on this last point. Shower baths should certainly be provided in plants involving very dirty work and at least to a limited extent should be provided in all plants. Efforts should also be made so to arrange and control machinery as to reduce noise to a minimum. Noise eliminators may be used at certain points.

Health Contributing Arrangements. A health bureau is today a well accepted fact in the best of manufacturing establishments. This involves, first, a proper hospital room and dispensary with adequate and suitable equipment therefor. Separate dressing rooms for men and women should also be provided in connection with an examining room which may in a small plant be joined with the hospital room. Equipment for optical work should be installed and many plants now have a special and fully equipped room for dentistry. A rest room for women with comfortable cots and toilet is almost a necessity. Recreation rooms for men and also for women are desirable, but not so necessary as the other features mentioned. Such rooms would be used for reading, study, music, sewing and games. They might be combined with the lunch room.

Factory Grounds. This article strongly recommends the original purchase of a site materially larger than required at the moment. This provides for expansion, but is at all times of real value. The advantages of providing for outdoor recreation of employes is too obvious to need emphasis. Baseball grounds, tennis courts, bowling greens, and spaces for volley ball and quoits will make good use of all land available. In congested areas more use should be made of roof gardens. A landscape architect should be consulted at the time the site is purchased and share in the decisions as to the exact location of the buildings and the proper allowance for foreground. He should also coöperate in laying out the grounds for appropriate landscape effects.